Meteorological Aspects of Two Modes of Lightning Triggered Upward Lightning (LTUL) Events in Sprite-Producing MCSs

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During the 2013 convective storm season, a high resolution 3-D Lightning Mapping Array was deployed to north central Kansas (Cummins et al, this conference.) In conjunction with fixed and mobile camera systems and electric field mills, this allowed for detailed investigations of lightning induced upward lighting (LTUL) discharges from tall objects in the region, including wind turbines. Also, concurrent observations using a network of low-light cameras deployed over the central U.S. as part of the PhOCAL program detected transient luminous events (TLEs) above the Kansas LMA (KSLMA).

During the night of 29-30 May 2013, waves of precipitation associated with several large MCSs traversing Kansas moved through the KSLMA domain. We focus on two LTUL events that exemplify two modes of upward lightning production from tall structures. At 0859Z, 30 May 2013, a nearby + 92 kA CG, with extensive in-cloud branching passing overhead a wind farm, was followed by complex LTUL discharges from four turbines. In addition, a sprite was confirmed by the Bennett, CO SpriteNet camera. The parent flash covered a very large area. It initiated near the MCS convective leading line ~150 km to the south, and traveled into a stratiform precipitation maximum over the KSLMA. Typically when a +CG precedes an LTUL, the triggering component is either 1) the return stroke that traverses the leader network which initially forms near the towers or 2) new negative leader activity that develops once the return stroke reaches the end of the initial leader network that may not have initially been near the tower. In the latter case, the new leader development passes near the towers and triggers upward positive leaders similar to those associated with only an intracloud flash. The +CG return stroke may hit >10 km from the towers and the new leader development may travel extensive distances before getting close enough to the towers to trigger upward lightning. In this case, there was the typical long delay between the +CG return stroke and LTUL initiation (10s to 100s of ms). The parent lightning discharges for both sprites and LTULs have many common aspects and tend to occur in similar meteorological regimes, with the two phenomena often occurring together.

An earlier LUTL, at 2320Z, 29 May 2013 was captured at 9900 fps by a Phantom camera in the PhOCAL mobile Lightning Investigation Vehicle (LIV). This discharge, exhibiting numerous recoil leaders, also occurred in a stratiform region some ~50-100 km north of an MCS convective core. While there was no preceding +CG, there was an extensive network of IC channels, one of which passed overhead close to the turbine.

These observations are consistent with the ongoing UPLIGHTS studies of LTULs from tall towers in Rapid City. While a +CG is usually involved (~85% of the time), the LTUL occurs because of the associated extensive in cloud components passing over towers. The earlier case without a +CG typifies this second mode where the triggering component is a negative leader associated with the IC activity passing near the towers initiates the upward positive leaders.

We will discuss the parent discharges, shown in their meteorological (radar and satellite) context, and attempt to better understand the charge structures present in both the convective and stratiform regions of the MCS. The sprite and its relationship to the parent discharge will similarly be discussed.